NASA TT F-11,057

NASA TT F-11,057

ASSEMBLY FOR DETERMINING THE TEMPERATURE DEPENDENCE OF THE THERMAL CONDUCTIVITY COEFFICIENT, THERMAL EMF, AND SPECIFIC ELECTRICAL RESISTANCE OF CERMET MATERIALS

S. N. L'vov, P. I. Mal'ko, and V. F. Nemchenko

Translation of "Ustanovka dlya opredeleniya temperaturnoy zavisimosti koeffitsiyenta teploprovodnosti, termo-E. D. S. i udel'nogo elektrosoprotivleniya metallokeramicheskikh materialov", *Poroshkovaya Metallurgiya*, Vol. 6, No. 9, pp. 89-91, 1966.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546 JUNE 1967

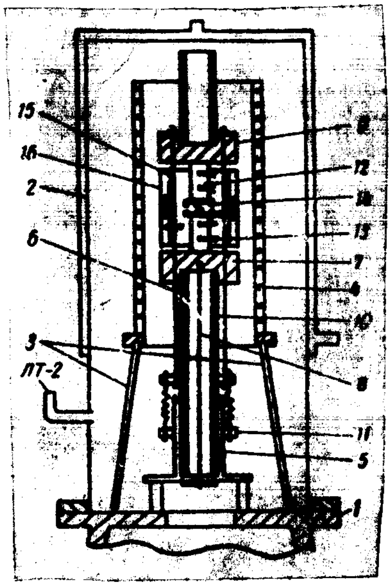
Experience has demonstrated that thin PtRh-Pt thermocouples lose their uniformity during prolonged heating to 1,000 to 12,000°C under conditions of an insufficiently high vacuum ($\sim 10^{-4}$ mm Hg) and introduce noticeable distortions in the results of measuring small temperature differences which are practically created on samples with good thermal conductivity. After a number of tests on various thermocouples made from inexpensive metals, it was established that thermocouples made from nichrome and pure nickel operate more stably than the PtRh-Pt thermocouple under the conditions that are created in the described assembly [2]. The wires that are used for the thermocouples must be thoroughly inspected for uniformity and calibrated through 30-50°C by means of a standard thermocouple. The "nichrome-nickel" thermocouple has an extremely linear temperature curve, can be used successfully for a number of times, and develops /91 an EMF approximately 2.5 times greater than that developed by the PtRh-Pt thermocouple; this naturally facilitates the measurement of small temperature differences. Moreover, it is quite simple to replace parts in these thermocouples. It should be borne in mind in this case that it is not necessary to completely replace a thermocouple; it is sufficient to replace only those parts which have been positioned in a region of intense heating.

The specific electrical resistance of the samples and their thermal EMF coefficient with respect to the material of one arm of the measuring thermocouples can also be determined simultaneously with the thermal conductivity measurement in the described assembly. To accomplish this, it is sufficient to additionally measure the voltage drop in sections of the samples between the measuring thermocouples in two directions of the current in the samples by using, for example, the nickel arms of the thermocouples as probes. The necessary supplemental data for determining the specific electrical resistance and the relative thermal EMF coefficient can be obtained by adding and subtracting the potentiometer readings obtained during the process.

REFERENCES

1. Mikryukov, V. Ye.: *Teploprovodnost' i elektroprovodnost' metallov i splavov. (Thermal Conductivity and Electrical Conductivity of Metals and Alloys.)* Metallurgizdat, 1959.
2. Angerer, E.: *Tekhnika fizicheskogo eksperimenta. (Techniques for Physics Experiments.)* Moscow, 1962.

FRANK C. FARNHAM COMPANY
133 South 36th Street
Philadelphia, Pa. 19104
Translated by Gerald E. Bernfeld
NASw-1497



means of fitting *5*; the cooler *7* for the lower sample is located on the upper end of the tube. It is attached to the tube by a molybdenum rod *8*. This rod serves simultaneously as one of the current supplies to the samples. The cooler *9* for the upper /90 sample is attached by three coiled springs across three rods *10*, which also serve as a second current supply. Coolers *7* and *9* are massive cylinders made from molybdenum and turned on a lathe. Another tube, exactly like tube *5*, is mounted in the upper cooler to create symmetrical heat transfer. The steel ring *11*, after compressing the springs, is secured by a fixing screw.

A furnace *14* is located between the samples *12* and *13*, which creates a temperature gradient along them. The furnace housing consists of two molybdenum half-cylinders with their bottoms isolated from one another by a hollow Alundum column. A molybdenum coil is placed inside it. Its ends are attached to the halves of the furnace housing. The current which passes through the samples also passes through the above-indicated coils. This completely eliminates heat losses by the heater coil through the current supplies. In order to obtain a sufficient temperature gradient, the heater must have an output on the order of 20 watts. A thick-walled molybdenum shield *15* is placed on top of the samples; there is also a heater made from molybdenum wire in the middle of the shield. The middle of the shield is heated to the temperature of the furnace between the samples, which eliminates heat losses from the lateral surface of the furnace and the samples. To ensure more uniform heating, the heater and the shield itself are protected on the outside by one more shield *16*. The furnace which provides the temperature gradient and the shield heater receive their power from separate storage batteries.

As experience has shown, owing to the symmetry of the assembly's measurement portion relative to its axis and with respect to the mean plane, the protection from lateral heat losses becomes more reliable. This is the main advantage of the method of simultaneously measuring the thermal conductivity coefficient on two samples.

A simple calculation indicates that the conventional formula $\lambda = Q\Delta l/S\Delta t$ (where Q is the output of the furnace between the samples, Δt is the total temperature difference on them, and Δl and S are the distances between the thermocouples and their cross-sectional areas, respectively), which follows from the Fourier equation, can be used in the case of samples which are similar in composition and identical in geometric dimensions to directly determine their mean thermal conductivity coefficient. The power is determined on the basis of the current and voltage on the heating coil; the current is determined on the basis of a voltage drop across a sample resistance. The voltage is measured between like arms of the thermocouple close to the furnace. All temperatures are measured with differential thermocouples. To ensure reliable thermal contact, the thermocouple wires are wedged with molybdenum pins in narrow openings which are drilled or broached by the electro-spark method.

ASSEMBLY FOR DETERMINING THE TEMPERATURE DEPENDENCE OF THE THERMAL CONDUCTIVITY COEFFICIENT, THERMAL EMF, AND SPECIFIC ELECTRICAL RESISTANCE OF CERMET MATERIALS

S. N. L'vov, P. I. Mal'ko, and V. F. Nemchenko

ABSTRACT. An assembly is described for measuring the thermal conductivity coefficient, thermal EMF, and specific electrical resistance of cermet materials at temperatures from 200 to 1200°C in a vacuum. The assembly accommodates two cylindrical samples simultaneously.

The assembly described below is intended for operation using cylindrical samples with diameters from 6 to 10 mm and lengths from 20 to 30 mm. Samples of this size and shape are the most convenient to fabricate from cermet materials. /89*

The thermal conductivity coefficient was measured in a steady-state heat flux along the axis of the sample on the basis of the application of the well-known Fourier equation [1], while the thermal EMF coefficient and the specific electrical resistance were determined by the potentiometric method. The assembly anticipates measurements in a vacuum within a temperature range of 200-1200°C.

As it is known, determination of thermal conductivity by the stationary method provides the most accurate results; however, it requires a longer period of time. Therefore, the measurements in the described assembly are conducted on two samples simultaneously, which practically reduces by half the time required for the measurement cycle and, most of all, makes it possible to set up a more reliable protection against heat losses.

The main components of the assembly and their relative positions are schematically represented in the figure**. The base of the assembly is a steel conical frustum *1*; all the parts are mounted on its upper flange and the current supply and thermocouple leads are made through it. The assembly is enclosed under a hood *2* with a cooling water jacket. A tripod *3* is installed on the upper flange. A cylindrical furnace *4*, which creates the primary heating, is attached to the tripod on Alundum columns. Its base is a thin-walled steel cylinder. The heater is made from molybdenum wire 1-2 mm in diameter and wound into a coil which encompasses the cylinder in the Alundum beads from turn to turn. Two shields made from molybdenum sheeting are placed on top of the coil. The heater obtains its power from a separate generator, owing to which high temperature stability is achieved.

A thick-walled Alundum tube *6* is attached to the flange, in its center, by

*Numbers in the margin indicate pagination in the foreign text.

**Translator's note: the designation ЛТ-2 in the figure was not explained in the text.